

# PROBABILISTIC MODELS

## COURSE SYLLABUS

<b>Code and name of specialty</b>	121 Software Engineering, 122 Computer Science, 126 Information Systems and Technologies	<b>Institute / faculty</b>	Faculty of Computer Science and Software Engineering
<b>Program name</b>	Software Engineering Computer Science and Intelligent Systems Information Systems Software	<b>Department</b>	Software Engineering and Management Information Technologies
<b>Type of program</b>	Educational and Professional	<b>Language of instruction</b>	Ukrainian

### Lecturer

#### Full name, e-mail

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**Doctor of Engineering Sciences, Professor, Professor of the Department of Software Engineering and Information Technologies of NTU "KhPI". Experience of pedagogical work - 23 years. Author of about 200 scientific papers, including 5 monographs, 6 textbooks and a textbook used in teaching such disciplines as "Technology Systems", "Optimization of monitoring systems", "Theory and practice of environmental management" for 10 years according to the developed textbooks, over 16 years the course "Ecology", the materials of which are provided in the textbook «Хімічна екологія : підручник–Сумський державний університет як підручник для студентів технічних ЗВО, протокол № 7 від 12.04.2018. – Суми: ПО» Видавництво «Університетська книга», 2018. – 460 с., навчальних посібників «Основы статистического учета в экологии». Гриф МОН України, лист № 14/18.Г-1959 від 09.11.07, Стандартизація. Екологічна стандартизація і метрологія. Навч. посібник. Гриф МОН України, лист № 14/18.2-2719, від 20.12.04– 228 с. At present, the training load includes courses "Green Computer", "Statistical Analysis and Planning of Scientific Experiment", practice "Models and Methods of Decision Support", Fundamentals of Python Programming (discipline of choice 02), Advanced course of Python programming (discipline choice 02)**

### GENERAL DESCRIPTION OF THE COURSE

<b>Summary</b>	During the study of the discipline the main attention will be paid to the essence of statistical models of modern financial, socio-economic processes, conditions of application of estimation methods of their parameters and research, scientific interpretation of analysis results and practical application of created models.
<b>Course objectives</b>	Study of the basic theoretical and practical provisions of construction of mathematical and statistical models of complex processes and practical use of analysis results for maintenance of scientific conclusions and hypotheses.
<b>Types of classes and control</b>	Lectures, laboratory work, consultations. Final control - credit
<b>Term</b>	3

<b>Student</b>	4 / elective	<b>Lectures (hours)</b>	32	<b>Workshops (hours)</b>	32	<b>Self-study (hours)</b>	56
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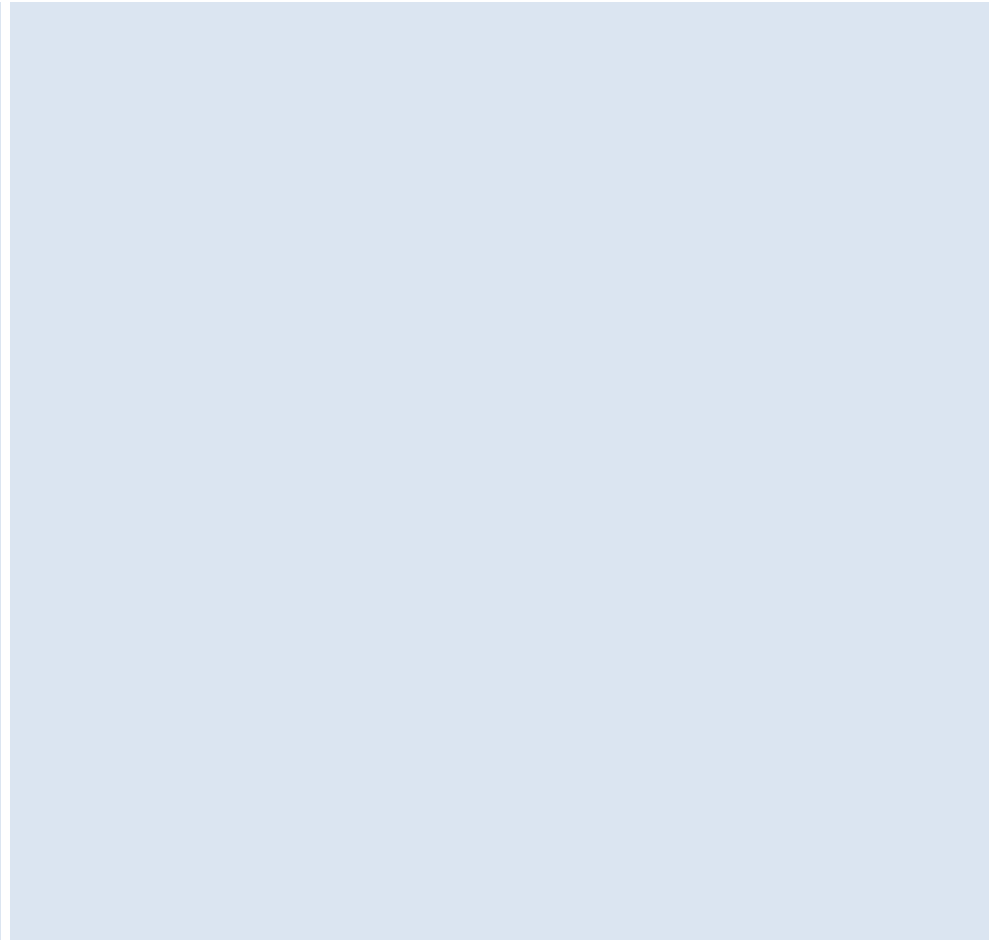
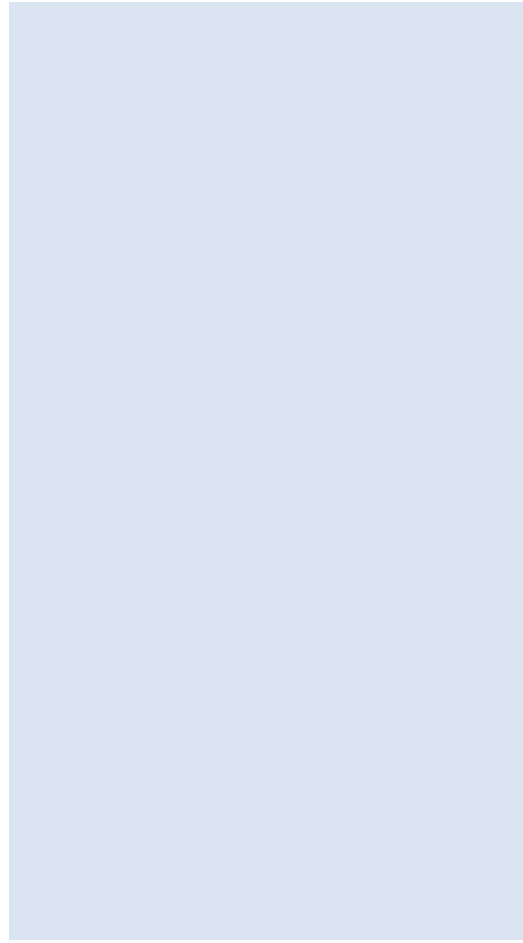
workload (credits) / Type of course						
<b>Program competences</b>	<p>121-GC 01. Ability to abstract thinking, analysis and synthesis.</p> <p>121-GC 02. Ability to apply knowledge in practical situations.</p> <p>121-GC 05. Ability to learn and master modern knowledge.</p> <p>121-GC 06. Ability to search, process and analyze information from various sources.</p> <p>121-PC19. Knowledge of information data models, the ability to create software for data storage, retrieval and processing.</p> <p>121-PC26. Ability to algorithmic and logical thinking.</p> <p>122-GC1. Ability to abstract thinking, analysis and synthesis.</p> <p>122-GC2. Ability to apply knowledge in practical situations.</p> <p>122-GC3. Knowledge and understanding of the subject area and understanding of professional activity.</p> <p>122-GC7. Ability to search, process and analyze information from various sources.</p> <p>122-PC6. Ability to think systematically, apply the systems analysis methodology to study complex problems of different nature, methods of formalization and solution of system problems with conflicting goals, uncertainties, and risks.</p> <p>122-PC19. Ability to comprehensively use for the creation of intelligent management systems methods of mathematical modelling and analysis of complex systems, methods of modelling and analysis of business processes, information technologies for the management of business systems.</p> <p>126-GC 1. Ability to abstract thinking, analysis and synthesis.</p> <p>126-GC 2. Ability to apply knowledge in practical situations.</p> <p>126-GC 3. Ability to understand the subject area and professional activity.</p> <p>126-GC 5. Ability to learn and master modern knowledge.</p> <p>126-GC 8. Ability to evaluate and ensure the quality of work performed.</p> <p>126-PC 1. Ability to analyze the object of design or operation and its subject area.</p> <p>126-PC 5. Ability to assess and take into account economic, social, technological and environmental factors at all stages of the life cycle of infocommunication systems.</p> <p>126-PC 13. Ability to perform computational experiments, compare the results of experimental data and solutions.</p>					
Learning outcomes	Teaching and learning methods	Forms of assessment (continuous assessment CAS, final assessment FAS)				
121-PO01. Analyze, purposefully search for and select the necessary information and reference resources and knowledge to solve professional problems, taking into account modern advances in science and technology.	Interactive lectures with presentations, discussions, practical classes, teamwork, case method, method of feedback from students, problem-based learning	Written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), rapid surveys (CAS), online tests (CAS), final / semester control in the form of a semester exam, according to the schedule of the educational process (FAS)				
121-PO18. Know and be able to apply information technology processing, storage and transmission of data.						
122- PLO3. Use knowledge of the laws of						

random phenomena, their properties and operations with them, models of random processes, and modern software environments to solve problems of statistical data processing and construction of predictive models.

122-PLO8. Use the methodology of system analysis of objects, processes, and systems for the tasks of analysis, prediction, management, and design of dynamic processes in macroeconomic, technical, technological, and financial objects.

126 - PLO 4. Conduct a systematic analysis of design objects and justify the choice of structure, algorithms and methods of information transfer in information systems and technologies.

126-PLO 5. Argue the choice of software and hardware for the creation of information systems and technologies based on the analysis of their properties, purpose and technical characteristics, taking into account the requirements for the system and operating conditions; have the skills to debug and test software and hardware of information systems and technologies.



### ASSESSMENT AND GRADING

Ranges of points corresponding to grades	Total score (points) for all types of learning activities	ECTS grading scale	The national grading scale	Allocation of grade points
	90-100	A	Excellent	
	82-89	B	Good	
	74-81	C		
	64-73	D	Satisfactory	
	60-63	E		
	35-59	FX	Unsatisfactory (with the exam retake option)	
	0-34	F	Unsatisfactory (with mandatory repetition of the course)	

**100% final assessment** as a result of credit (40%) and continuous assessment (60%).  
**40% credit:** ...  
**60% continuous assessment:** ...

#### Course policy

The policy of the academic discipline is determined by the system of requirements for the study of the discipline, the inadmissibility of omissions, the

implementation of the required minimum of educational work; incentives and penalties - scoring or subtraction of points. The policy of the academic discipline is based on the norms of the legislation of Ukraine on academic integrity, the Charter, the provisions of NTU "KhPI": • results reduction of control work, exam; • re-assessment of control work, exam; • appointment of additional control individual tasks, tests, tests.

### COURSE STRUCTURE AND CONTENT

<b>Lecture 1</b>	Methodological bases of statistical analysis and forecasting Theoretical foundations of statistical analysis, modeling and forecasting of mass processes ..	<b>Practical lesson 1</b> Laboratory work №1. Probabilistic models of distribution laws. Laws of distribution of discrete quantities. Laws of distribution of continuous quantities.	Laws of distribution of discrete quantities.	<b>Self-study</b>	Data sources for statistical analysis. The results of business processes of enterprises as internal data sources. Information support of their receipt, storage and processing.
<b>Lecture 2</b>	The essence of modeling. Modeling in scientific activity. Stages of the modeling process. Purpose and object of modeling. Analysis and interpretation of simulation results. Principles of forecasting.	<b>Practical lesson 2</b> -Laboratory work №2 Data sources for statistical analysis. Sample population as a data source that represents the research object for statistical analysis and modeling.	Normal distribution law and its properties.		Databases and data warehouses (Date Warehousing). Operational analytical data processing (OLAP). The concept of "data mining" (Data Mining). Growth of data volumes and frequencies (Big Data).
<b>Lecture 3</b>	Statistical estimation of parameters of mass processes and bases of statistical conclusion. Statistical testing of hypotheses	<b>Practical lesson 3</b> -Laboratory work №2 Analysis of variance and its application in scientific research.	Basic statistical hypotheses and criteria for their verification		Statistical parameters of distributions of indicators of mass processes and their estimation. Estimation of statistical parameters with a given probability.
<b>Lecture 4</b>	Statistical modeling of relationships between indicators and experimental results	<b>Practical lesson 4</b> Modular control 1. Delivery of laboratory works	Classical correlation-regression analysis		Violation of assumptions about the classical correlation-regression analysis: multicollinearity, heteroskedasticity, autocorrelation, methodological approaches to their elimination.
<b>Lecture 5</b>	Nonlinear regression: reduction of models to linear form, logarithmization, prediction based on nonlinear models.	<b>Practical lesson 5</b> Laboratory work №3 Modeling of causal relationships: socio-economic processes. Correlation-regression analysis. Checking the adequacy of models.	Non-parametric methods of relationship analysis.		Basic concepts of experimental planning theory: plan, factor, factor level. Complete factorial experiment. Effects of interaction of factors.
<b>Lecture 6</b>	Analysis of one-dimensional dynamic processes and their forecasting. Models of stationary time series. Adaptive forecasting models. Moving average model (MA).	<b>Practical lesson 6</b> Laboratory work №3 Modeling of causal relationships: Interpretation of the obtained results.	Exponential smoothing and forecasting.		Identification of the main development trend: trend models of the time series; types of trend models. Seasonal decomposition; spectral analysis.
<b>Lecture 7</b>	Box-Jenkins time series analysis: model identification of ARtMA models, model evaluation, model diagnostics, residual analysis, model comparison, numerical criteria of model adequacy.	<b>Practical lesson 7</b> Reports on laboratory work №1, 2, 3	Classical estimation of unknown coefficients.		Models of autoregressive conditional heteroskedasticity, conditions of their application and analysis. Models with variable variance: ARCH, GARCH, TGARCH and others. Evaluation of models with variable variance.
<b>Lecture 8</b>	Complex analysis and models of dynamic processes: Models of vector autoregression.	<b>Practical lesson 8</b> Laboratory work №4 Models with variable variance:	Pulse analysis Structural analysis		Examples of modeling systems of macroeconomic indicators to determine the impact of government policies

	Evaluation of stationary VAR-models.	ARCH, GARCH, TGARCH and others. Evaluation of models with variable variance.		and external factors in order to analyze possible development scenarios.
<b>Lecture 9</b>	Comprehensive analysis and models of dynamic processes: modeling of time series when the economic situation changes (structural changes). Economic analysis based on models with changing economic situations.	<b>Practical lesson 9</b> Laboratory work №4 Models with variable variance: features of their application in the analysis of financial processes.	Pulse analysis Structural analysis	Examples of modeling systems of macroeconomic indicators to determine the impact of government policies and external factors in order to analyze possible development scenarios.
<b>Lecture 10</b>	Panel data models Features of panel data and their importance in financial and economic activities. Panel data structure: hidden variables and individual effects.	<b>Practical lesson 10</b> Modular control 2. Delivery of laboratory works	Hausmann test to compare models	Creation and analysis of models with fixed effects: evaluation of model coefficients, verification of the significance of group effects, evaluation "within groups" and "between groups".
<b>Lecture 11</b>	Panel data models Models with random effects. Estimation by the generalized method of least squares.	<b>Practical lesson 11</b> Laboratory work №5 Special regression models: logit and probit models and binary variable prediction.	Least squares method	Study of stationarity of models with panel data. Forecasting based on panel data models.
<b>Lecture 12</b>	Statistical models of classification in scientific activity Classification models in financial and economic activities.	<b>Practical lesson 12</b> Laboratory work №5 Special regression models: Classification based on special regression models.	Hausmann test to compare models	Examples of using panel data models in the analysis of enterprise groups, regions, countries.
<b>Lecture 13</b>	Statistical models of classification in scientific activity: Multidimensional ranking. Classification without training sample. Cluster classification procedures. Hierarchical methods of classification. Classification based on the training sample.	<b>Practical lesson 13</b> Laboratory work №5 Special regression models: Comparative analysis of classification methods in scientific activity.	Method $\hat{\lambda}$ -average	Discriminant function and evaluation of its parameters. Classification based on discriminant function.
<b>Lecture 14</b>	Statistical models of latent variables in research: The concept of latent variables. Methodological principles of construction of models of latent variables.	<b>Practical lesson 14</b> Laboratory work №5	Methods for estimating the parameters of models with latent variables	Examples of the use of classification models
<b>Lecture 15</b>	Statistical models of latent variables in research: Models of structural equations with latent variables. Stages of creating models .. Quality indicators, compliance of models.	<b>Practical lesson 15</b> Modular control 2. Defense of laboratory works	Methods for estimating the parameters of models with latent variables	Causal and reflecting the observed indicators of latent variables. Identification of latent socio-economic factors.
<b>Lecture 16</b>	Statistical models of latent variables in research: Examples of modeling psychological, socio-economic, financial and	Delivery of laboratory works, credit	Methods for estimating the parameters of	The main components method. Confirmatory factor analysis

## 1. RECOMMENDED READING

Compulsory

1. Геєць В. М. [та ін.] (2010). Економічні дослідження (методологія, інструментарій, організація, апробація): навч. посібник / за ред. А. А. Мазараки; Київ. нац. торг.-екон. ун-т. Київ: б. в., 279 с.
2. Бахрушин, В. Є. (2011). Методи аналізу даних: навч. посібник для студ. / В. Є. Бахрушин. Запоріжжя: КПУ, 268 с.
3. The Methods of Data Analysis (in Ukrainian). [Electronic resource]. Access mode: <http://www.researchgate.net/publication/235825660>
4. Єлейко, В. І. (2011). Економетричний аналіз діяльності підприємств: навч. посібник / [уклад. : В. І. Єлейко, Р. Д. Боднар, М. Я. Демчишин]. Львів: Львівська комерційна академія, 368 с.
5. Єріна, А. М. (2001). Статистичне моделювання та прогнозування. Київ: КНТЕУ, 196 с.
6. Лук'яненко, І. Г., Городніченко Ю. О. (2003). Сучасні економетричні методи в фінансах. Київ: Літера, 348 с.
7. Присенко, Г. В., Равікович Є. І. (2005). Прогнозування соціально-економічних процесів: навч. посібник. Київ: КНЕУ, 378 с.
8. Мاستицкий, С. Э., Шитиков, В. К. (2014). Статистический анализ и визуализация данных с помощью R. Москва: ДМК-пресс, 496 с.
9. Электронная книга. [Электронный ресурс]. Режим доступа: <http://r-analytics.blogspot.com/>
10. Чорний, А. Ю. (2011). Статистика якості. Практикум: навч. посібник. Київ: Київ. нац. торг.-екон. ун-т, 264 с.

Recommended

1. Пономаренко, В. С., Малярець Л. М. (2009). Багатовимірний аналіз соціально-економічних систем: навч. посібник. Харків: Вид. ХНЕУ, 384 с.
2. Грін Вільям Г. (2005). Економетричний аналіз: підручник / пер. з англ. наук. ред. пер. О. Комашко. Київ: Вид-во Соломії Павличко «Основи», 1197 с.
4. Касьяненко, В. О., Старченко Л. В. (2006). Моделювання та прогнозування економічних процесів: навч. посібник. Суми: Універ. кн., 185 с.
5. Канторович, Г. Г. Лекции по курсу «Анализ временных рядов». *Экономический журнал ВШЭ*. № 1-4, 2002. № 1, 2003.
6. Куфель, Т. (2007). Эконометрика: решение задач с применением пакета программ GRETЛ. Москва: Телеком, 200 с.
7. Геєць, В. М., Клебанова, Т. С., Черняк О. І. та ін. (2008). Моделі і методи соціально-економічного прогнозування: підручник. 2-ге вид. Харків: ІНЖЕК, 396 с.
8. Мамчич, Т., Оленко, А., Осипчук, М., Шпортюк, В. (2006). Статистичний аналіз даних з пакетом STATISTICA. Дрогобич: Відродження, 208 с.

**Інтернет-ресурси**

1. Сайт спільноти пакету економетричного моделювання *ЄЯЕТЬ*. [Електронний ресурс]. Режим доступу: <http://gretl.sourceforge.net/index.html>
2. Інтернет-сайт середовища програмування і пакетів статистичних програм і графіки Я. [Електронний ресурс]. Режим доступу: <http://www.r-project.org/>
3. Шипунов, А. Б. [и др.]. (2012). Наглядная статистика. Используем Я! Москва: ДМК Пресс, 296 с. [Электронный ресурс]. Режим доступа: <http://ashipunov.info/shipunov/school/books/rbook.pdf>

**Academic integrity**

The student must adhere to the Code of Ethics of Academic Relations and Integrity of NTU "KhPI": to show discipline, politeness, friendliness, honesty, responsibility

The content of this syllabus is consistent with the course program